

Control of

Grape

DISEASES

and INSECTS

in Eastern United States

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DISEASES AND INSECTS, important among which are black rot, downy mildew, anthracnose, grape berry moth, and grape leafhoppers, cause serious damage to growing grapes in eastern United States. The control of these and other diseases and pests is an important factor in the production program if grapes of high quality are to be harvested, and no grower can afford to neglect the necessary control measures.

This bulletin gives information on the best available measures for the control of the most important diseases and insects to which the grape is subject in the States lying east of the Rocky Mountains. For that region this bulletin supersedes Farmers' Bulletin 1220, Insect and Fungus Enemies of the Grape.

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CONTROL OF GRAPE DISEASES AND INSECTS IN EASTERN UNITED STATES

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INTRODUCTION

DAMAGE DONE TO GRAPES in the United States by fungus diseases and insects varies considerably in different regions and from year to year. Weather conditions during the critical periods for infection may either favor or suppress the development and spread of the organisms causing the diseases. In some districts in the Northern States grape diseases are so easily controlled that in most years one or two applications of bordeaux mixture spray are sufficient for control, whereas in other years the full spray program is hardly adequate. Grape diseases are most prevalent and more difficult to control in the Southeastern States because of prevailing high temperatures, abundant rainfall, and a long growing season.

The grape is subject to attack by a large number of insects only a few of the more important of which are mentioned in this bulletin. The general control program suggested on page 27, however, will in most cases prove adequate for the control of the insects most commonly encountered. For information on problems not dealt with herein, it is suggested that the readers write to their State agricultural experiment stations or to the United States Department of Agriculture, describing the injury in detail and sending specimens. Living insects should not be sent through the mail; they should be killed and sent dry or preserved in alcohol or formalin.

Conditions in small home vineyards, however, are often so favorable for both insects and parasitic fungi that control is difficult. The few vines usually grown in home gardens are often trained on the side of a building, on an overhead trellis, or in some location where they receive sunshine only a portion of the day. Vines so grown cannot be pruned and sprayed properly; if shaded part of the day they will be in an environment favorable for the development and spread of fungus parasites, thus making control difficult, if not impossible.

¹ Deceased July 11, 1941.

DISEASES PRINCIPALLY OF AMERICAN BUNCH GRAPES

Varieties and types of grapes grown influence the amount of disease. The vinifera, or European, varieties as a class are very susceptible and cannot be grown successfully east of the Rocky Mountains, except in a few favorable districts. Varieties of the American bunch grape vary widely as to susceptibility to diseases. The muscadine group of grapes, of which the Scuppernong is a representative, are highly resistant to the more destructive diseases.

The organisms that cause the most important grape diseases hibernate on the previous year's vines, leaves, and fruits and may become active again very early in the spring. Then new spores are produced that infect the young leaves and vines and later the blossoms and fruits. Winter pruning of the surplus vine growth and cultivation of the soil will dispose of a large amount of the infectious material, but enough may remain to spread the disease thoroughly unless spray is applied early in the spring.

BLACK ROT

Black rot, caused by *Guignardia bidwellii* (Ell.) Viala and Ravaz, is the most widespread disease of grapes and in the eastern grape-producing regions causes greater loss than all other diseases combined. It is quite generally distributed in most grape-growing areas east of the Rocky Mountains, but it is most prevalent and destructive east of the Mississippi River and is especially destructive in the hotter, humid portion of this area and west along the Gulf coast of Louisiana and Texas. All vinifera, or European, varieties of grapes and many of the American bunch grapes are highly susceptible to attack by the black rot fungus. A few American bunch grape varieties that may be listed as having considerable resistance and good table qualities are Campbell Early, Delaware, Diamond, Dracut Amber, Eaton, Lucile, Lutie, Moore Early, Portland, and Worden. Concord is hardly resistant enough to be included in this list.

The fungus causing black rot may attack the leaves, shoots, blossoms, and fruits of the bunch grapes. Only the young and tender tissues are infected. Even the fruit becomes highly resistant after it has attained about full size. Rotting of the fruits after they begin to color is usually caused by other fungi.

Although spotting occurs on the leaves (fig. 1) and vines in early spring, the disease does not attract much attention until midsummer, when the nearly half-grown berries begin to rot. The disease of the fruit begins to show as light-brownish, soft circular spots; these increase rapidly in size, and the surface becomes somewhat sunken. After 3 or 4 days small black dots appear on the surface of the decayed areas and later become so numerous as to make a dense black spot. As the rot progresses the entire berry decays and within a week or 10 days is transformed into a hard, black, shriveled mummy. The dead, shriveled berries may remain attached to the bunch for several weeks (fig. 2). Some shattering of the berries may occur, depending on the variety, during the period of rapid decay and before drying of the berries takes place. After they become mummified they are not readily dislodged. The attached mummy fruits are covered with very small pimplelike structures that contain spores.

The fungus causing the disease lives through the winter in a dormant condition, but on the return of warm, moist weather in the spring new spores that infect the young leaves and shoots are produced; thus the rot organism is perpetuated from one season to another. The abundance of the disease from season to season depends on how favorable are the weather conditions during spring and early summer and on the amount of diseased material carried over from the previous season on the vines and fallen leaves and fruits.



FIGURE 1.—A bunch grape leaf attacked by black rot fungus.

Control

If the vines are not sprayed early, the fungus, if present in abundance, may attack the young shoots and foliage and build up a great reservoir of spores which infect the fruit later in the season. An early application of bordeaux mixture is very important to prevent this early vine infection (see pp. 26 and 27). In vineyards where black rot has caused considerable loss, this first application should be made when the new shoots have made a growth of only 1 or 2 inches. If rot has not caused much damage previously, the first application can be delayed until the new vine growth is 7 to 8 inches long, with a second application immediately before blossoming. Two or three applications should be made after the blossoming period, one immedi-

ately after the fruit has set, a second when the grapes are about the size of peas, and sometimes, especially in the South, a third is necessary about 10 days or 2 weeks later. In regions where black rot does not usually cause serious loss, one or two prebloom sprays and one or two after-bloom applications are usually sufficient. The spray schedule given on page 27 is meant for average conditions and to serve as a guide to the probable number of applications of spray and the approximate times of application required for protection against grape diseases. Since black rot and some other grape diseases are more destructive in the Southern States, where rain is more abundant and the growing season longer, a greater number of applications are



FIGURE 2.—Cluster of grapes showing black rot injury. Note the attached mummified berries.

required there, and it is suggested that readers in those States write to their State agricultural experiment stations for detailed information on spray schedules.

DOWNY MILDEW

Downy mildew, caused by *Plasmopara viticola* (B. and C.) Berl. and De Toni, is primarily a disease of grape foliage. It often becomes quite destructive to the leaves of unsprayed vineyards located in the Ohio River Valley, the Great Lakes region, and northeastern United States as far south as southern Virginia. Since the fungus causing downy mildew is favored by cool, moist weather, the disease is of minor importance in the South. The older leaves in the center of the vine are the first to become infected. The disease spreads from the foliage at the center toward that at the ends of the canes as the leaves

mature, and by autumn on highly susceptible varieties even the last leaves formed may succumb, the result being complete defoliation. On the other hand, if the season has been unfavorable for the spread and rapid growth of the fungus or if the variety is resistant, only a few of the oldest leaves may show the disease.

The fungus lives over winter in the old affected leaves on the ground. The action of weathering and decomposition liberates the spores during the spring. By the aid of rain splashing or wind some find their way to the leaves or fruits, where initial infection takes place. Only



FIGURE 3.—Downy mildew on the under side of a grape leaf.

minor damage is done to the foliage before late summer. The greatest damage occurs during August and September.

The first evidence of infection on the leaves appears as light-yellow spots, as seen from above. Later a white moldy growth, made up of fungus threads and spores, forms on the under surface of the leaves (fig. 3). The spots may be few or numerous, and by uniting they may involve most of the leaf surface. Invasion of the fungus kills the leaf tissues and then affected portions turn brown. Such leaves finally become dry and crumpled and fall, thus exposing the clusters of fruit to burning by the sun. Vines losing their leaves before the ripening

season cannot mature the fruit normally; consequently, it is of inferior quality.

The disease may also attack the shoots, tendrils, and fruit (fig. 4). Such parts are attacked early in the season when they are more tender. Infections on the new growth and young fruits show as water-soaked depressions, without any other diagnostic characters, unless there is a



FIGURE 4.—Tips of grapevine killed by downy mildew.

development of white moldy growth similar to that on the under side of the leaves.

During years when the fruit is attacked, there may be two waves of infection during the season, the first occurring in June, when the grape berries are about the size of small peas. When the berries are infected at this period they become soft, shatter easily, and are frequently covered with the white, downy growth of the causative fungus. During the hot part of the summer there is less evidence of mildew rot, but upon the approach of cooler nights the second wave of injury may occur. As a rule the fruits infected at this time do not soften and show the downy growth, but instead they become brownish in color, wither, and shatter easily.

Control

Downy mildew of grapes is comparatively easy to control and seldom does damage in vineyards that are sprayed regularly for protection against black rot. The spray schedule recommended on page 27, if followed, will effectively control downy mildew.

ANTHRACNOSE, OR BIRD'S-EYE ROT

Anthracnose, caused by *Elsinoë ampelina* Shear, occurs in some sections in the eastern half of the country, in both the northern and the southern part, but it is usually localized and confined to a few varieties. It may do considerable damage in a vineyard or a locality for a few years and then disappear.

Anthracnose has not been reported on the variety Concord, the most widely grown variety in the Eastern States. Other highly resistant eastern varieties are Beacon, Delaware, Herbemont, Niagara, Moore Early, President, and Lutie. The most susceptible varieties reported are Champion, Catawba, Diogenes, Campbell Early, Diamond, Ellen Scott, Norton, and Salem.

The effect of the disease on the fruit and other parts of the vines is quite striking and not easily confused with other grape diseases. In addition to the fruit, the young shoots, tendrils, petioles, leaf veins, and fruit stems may also be attacked severely.

Numerous spots sometimes occur on the young shoots; some will unite and cause girdling, which results in the death of vine tips. Similar spots develop on the petioles and leaves, especially on the under surface of leaves. Badly infected leaves curl downward from the margins, becoming distorted and spotted, and the diseased areas drop out, giving the leaf a ragged appearance.

On the fruit the spots are circular, sunken, and ashy gray in color; in the later stages they are surrounded by a dark-colored margin. The name bird's-eye rot, sometimes applied to this disease, is derived from the appearance of the spots on the berries (fig. 5).

Control

Four or five applications of bordeaux mixture as directed for the control of black rot, in addition to an application of lime-sulfur solution at the strength of 1 gallon of concentrated lime-sulfur to 9 gallons of water during the dormant season, have given good control. It is also advisable to remove and burn all affected parts as they appear.

RIPE ROT AND BITTER ROT

Other rots that appear on the fruits after they begin to color are known as ripe rot, caused by *Glomerella cingulata* (Stonem.) Spauld. and V. Schrenk, and bitter rot, caused by *Melanconium fuligineum* (Scrib. and Viala) Cav. There are no clear-cut diagnostic features by which growers distinguish these two, except that the fungus causing bitter rot imparts a bitter taste to decayed berry pulp.

Control

These diseases are not troublesome in vineyards well sprayed as recommended for black rot on page 3. Since these diseases do not

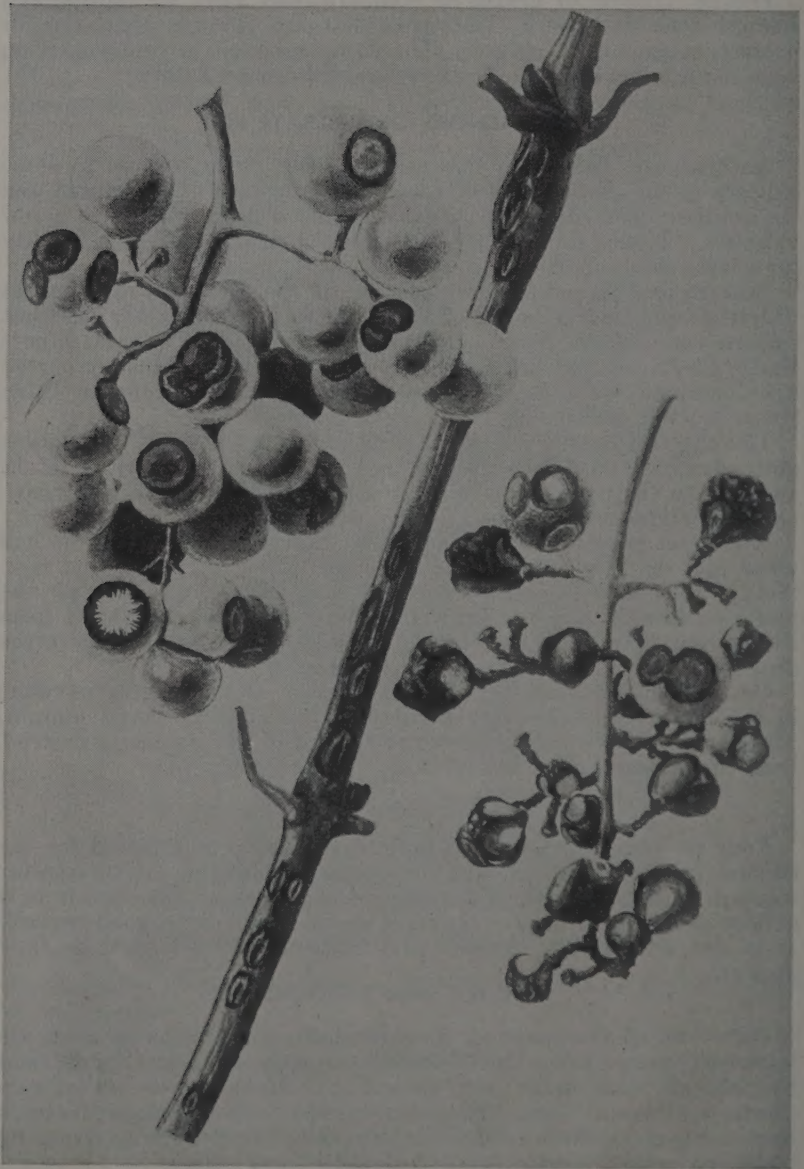


FIGURE 5.—Anthracnose, or bird's-eye rot, on fruit and vine of grape. (Photographed from painting by J. M. Shull.)

appear until the grapes begin to mature; the later applications of spray made for control of black rot are especially important for protecting the berries during the ripening season.

DEAD ARM

Dead arm is primarily a disease of the trunk and main branches of the vine. It has been reported from several States in the north-eastern part of this country. An epidemic of the disease has never been recorded, and the total loss each year is only nominal; nevertheless, the disease has been found in many vineyards.

The disease is caused by a fungus (*Cryptosporella viticola* Shear) that attacks the young shoots, the trunk, or branches, gaining entrance frequently through wounds or in parts affected by winter injury. After once entering the woody tissues the fungus lives there year after year as a perennial parasite. The infected tissues are killed, forming a canker that enlarges each year, finally girdling the arm or trunk and causing the death of the portion of the vine above the canker.

If the arm or trunk is girdled, the entire vine above the canker dies and new shoots are put out from the portion below the canker. If the affected branch or trunk is only partially girdled, the new shoot growth developed above the canker will be weak and the foliage dwarfed and curled. If such shoots survive the season, they usually succumb during the following winter.

Control

The dead arm cankers produce innumerable spores capable of starting new cankers elsewhere. Diseased vines should be taken out and burned as soon as they are found. Observations in Delaware have shown that a delayed dormant spray with bordeaux mixture early in the spring when the new buds are beginning to open is an aid in preventing new infections with the dead arm disease fungus.

POWDERY MILDEW

Powdery mildew, caused by *Uncinula necator* (Schw.) Burr., is present in many vineyards but is of small economic importance in the eastern half of the United States. However, it is considered the most damaging fungus disease of vinifera grapes in California.

East of the Mississippi River powdery mildew is very largely a disease of the foliage. It shows on the upper side of grape leaves as a white, mealy, superficial growth (fig. 6). Severely affected leaves turn brown and fall. If berries are infected, they have a russeted or scurfy appearance on the surface. They fail to mature properly, but no rot is associated with this injury.

Control

This disease is absent in vineyards sprayed for combating black rot and downy mildew; therefore in localities where the disease does damage to either foliage or fruit the spray schedule outlined on page 27 is recommended.

ROOT DISEASES

The roots of grapes are known to be attacked by several different organisms causing either swellings or decay. Root troubles are not easily diagnosed, and it is often necessary to take out a plant or a portion of the root system in order to make an examination of suspected root diseases. In general, the symptoms of root diseases are slow growth of the vine, low productivity, small, scant, yellowish leaves, and wilting. Soils known to be infested with the cotton root rot or crown gall organisms should not be planted to grapes. Little or nothing can be done to remedy such troubles after they become established in a vineyard.

Crown Gall

Crown gall, although not a serious grape disease in eastern United States, is conspicuous on the vines when it does occur. This bacterial disease is caused by *Phytophthora tumefaciens* (Smith and Town.) Bergey et al., and is ordinarily considered to be a wound parasite of the roots and trunk. When the roots are affected, large galls more or less spherical in shape are found, usually near the ground line. Sometimes the galls attain the size of a walnut. The form most frequently seen occurs on the branches or main trunk as numerous small galls crowded on an elongated swelling of the vine trunk (figs. 7 and 8).

Control

Because the organism producing the disease lives in the soil, it cannot be controlled by spraying. Where galls are confined to the branches or trunk, these should be removed far enough below the gall to include all affected tissue. New plants can be examined before planting, and any showing evidence of galls should be discarded. The crown gall organism is widely distributed and attacks various fruit trees and shrubs.

Cotton Root Rot

The cotton, or Texas, root rot disease occurs chiefly in Texas, Oklahoma, and States westward. It is caused by the soil-infesting fungus *Phymatotrichum omnivorum* (Shear) Duggar and attacks the roots of many plants in addition to grape. Conditions favorable for the growth and spread of the fungus are high soil temperature, abundance of moisture, and highly alkaline soils.

A dull yellowish appearance of the foliage and a tendency of the plants to wilt during midafternoons are early symptoms. Badly affected plants may die suddenly; the disease spreads from plant to plant, involving ever-widening circles around the first plant to die. The root system of affected plants shows extensive killing and decay. A network of buff-colored fungus strands is abundant on the surface of diseased or dead roots. During the summer, when frequent rains occur, the fungus produces conspicuous spore mats on the surface of the soil under or near affected vines. At first these spore mats have the appearance of cotton, but later they become buff-colored and powdery.

Control

As stated previously, grapes should not be planted on areas infested by the cotton root rot fungus. The disease is difficult to com-

bat if the causal fungus becomes established in a vineyard; therefore, prompt treatment is essential to prevent rapid spread. An application of ammonium sulfate or ammonium phosphate at the rate of 10 pounds to 100 square feet of soil surface just before a rain if possible or followed by a 3-inch irrigation if available is recommended. The treatment should extend somewhat beyond the area of dead vines.



FIGURE 6.—Powdery mildew on the upper side of a grape leaf.

DISEASES OF MUSCADINE GRAPES

The fruit of the muscadine group of grapes, represented by such varieties as Scuppernong, Mish, James, and Thomas, are relatively free of diseases. Black rot, the most damaging disease of the fruit of the American bunch grape, does a negligible amount of damage to the muscadine fruit. Infection by black rot as a rule does not cause decay on muscadines, but results in a black, shallow, hard, scablike defect.

The blossoms, however, are susceptible to attack by the black rot fungus. A few days of cloudy, rainy weather during the blossoming period will favor infection and sometimes result in a heavy drop of

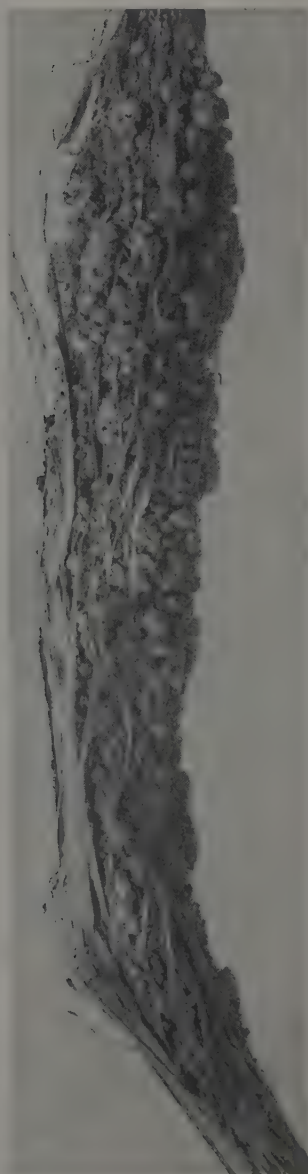


FIGURE 7. Numerous small wartlike galls caused by the crown gall organism in a grape trunk.

blossoms. The black rot fungus causes considerable spotting on the foliage of muscadine grapes. In seasons favorable for the fungus, the spots are rather conspicuous and numerous, and a large portion of the leaf area may be destroyed (fig. 9). The foliage of Scuppernong and Mish varieties is very susceptible to this disease.

The bitter rot fungus attacks the fruit during the ripening season and causes some decay and shattering; however, some varieties of the muscadine grapes shatter badly, irrespective of the presence of diseases. In the Southern States this disease causes greater loss in muscadine vineyards than any other disease.

Two other fungi (*Cercospora* sp. and *Isariopsis clavispora* (B. and C.) Sacc.) attack the old foliage of muscadine grapes after midseason.



FIGURE 8.—Crown gall on a grape root at the surface of the soil.

The effect of the one known as *Cercospora* is not very noticeable, although infections may be abundant. On the upper surface of the leaf the disease appears as yellowish-green areas one-fourth of an inch or more wide. The spores are produced on the lower surface and appear as brown, feltlike patches. After the spores are washed away, these patches appear as faint-brownish areas (fig. 10). *Isariopsis* makes more conspicuous markings, which appear as large, dark-brown spots one-fourth to one-half of an inch in diameter. Frequently the spot is circular, surrounded by an almost perfect circle, with a narrow band of normal leaf color lying between the spot and the circle. Spots show on both surfaces of the leaf.

Downy mildew rarely attacks the muscadine grapes.

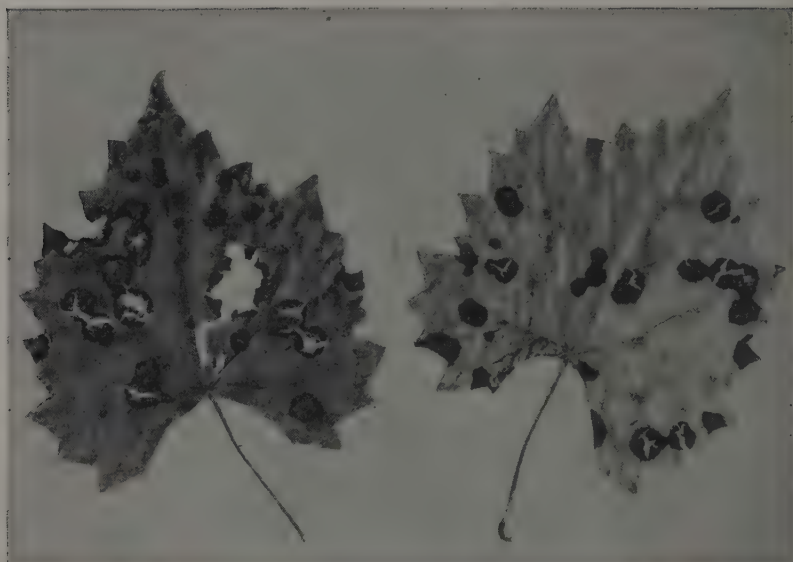


FIGURE 9.—Spots caused by the black rot fungus on leaves of the muscadine grape.



FIGURE 10.—A muscadine grape leaf spotted by *Cercospora*.

CONTROL

Very little can be said about the treatment of muscadine vineyards to combat disease, as only a small amount of experimental work has been done. Owners of muscadine vineyards do not spray, but they seldom have a crop failure. Spraying with bordeaux mixture during the summer will help keep the foliage free of diseases, but it is generally thought that the benefit derived from spraying is not sufficient to offset its cost.

INSECTS

GRAPE BERRY MOTH

Grapes are frequently injured by the larva of the grape berry moth (*Polychrosis viteana* (Clem.)), an active greenish caterpillar



FIGURE 11.—Clusters of grapes injured by larvae of the grape berry moth.

about three-eighths of an inch long when full-grown. Larvae of the first brood of this pest feed in the blossoms or very young fruit clusters and in the newly formed berries; those appearing later injure the green and ripening berries (fig. 11), often causing serious losses. One larva may injure several berries in turn. On completing their feeding, the caterpillars leave the berries, and each cuts out a small bit of grape leaf, folds it over, and constructs a cocoon within the fold (fig. 12). This cocoon usually falls out of the leaf and drops to the

ground. The winter is passed in the cocoon, and late in the spring or early in the summer the inconspicuous brownish moths (fig. 13) emerge and lay their eggs on the grape stem or berries. The grape berry moth is found over most of the eastern half of the United States

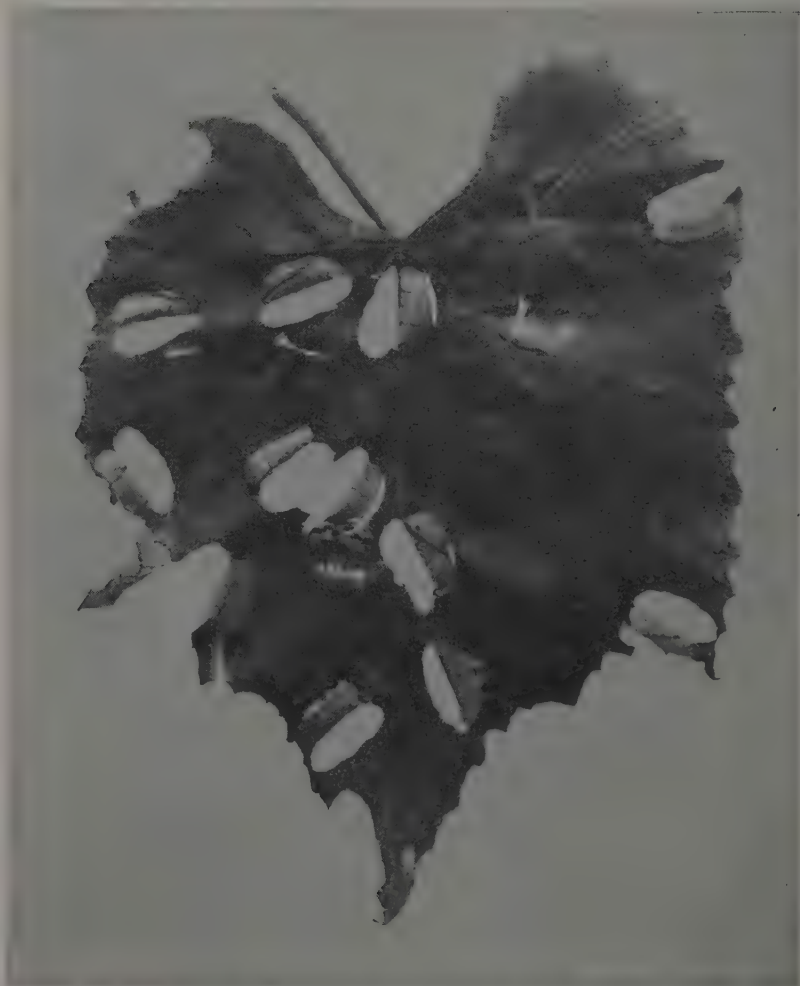


FIGURE 12.—Cocoons of the grape berry moth on a fallen grape leaf. The cocoons are scarcely visible, being largely hidden under the small flap of leaf material cut and turned over.

and is especially troublesome in the area north of the Ohio River and east of the Mississippi River and on through New England.

Control

To control the grape berry moth a combination of methods is suggested. Experiments and observations in vineyards in northern Ohio have shown that certain cultural practices aid materially in

reducing the overwintering population. Plowing or cultivating in the fall should be avoided, so that the overwintering cocoons will be left on the surface of the ground during the winter and thus exposed to natural destructive agencies. In the spring, however, the cultivation should be such as to bury the cocoons beneath the surface of the ground and leave them undisturbed until after the time of maximum emergence of the moths. A comparatively shallow covering of soil is sufficient to prevent the moths from coming out of the ground. In vineyards where these practices have been followed the number of surviving insects has been reduced to a point where a shortened spray schedule has given a satisfactory degree of grape berry moth control.

After the cultural treatment just described has been used two applications of calcium arsenate or lead arsenate should be made at a strength

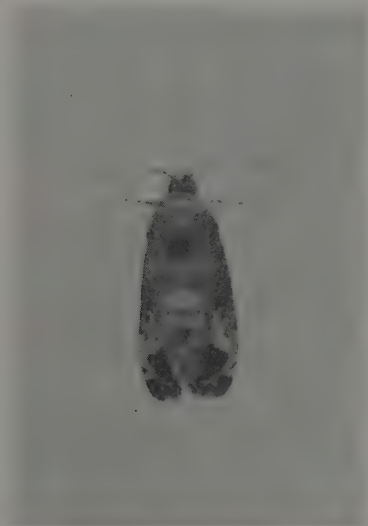


FIGURE 13. Adult of the grape berry moth. (About $5\frac{1}{2}$ times natural size.)

of 1 pound in 50 gallons of bordeaux mixture, with a sticker; the first application should be made just before the blooming period and the other just after it. (See general spray program, p. 27, and precautions, p. 26.) It is essential that thorough work be done in these two spray applications, since spraying against the later broods cannot be recommended because of the danger of having excessive spray residues on the fruit when it is harvested. Investigations are under way to develop less objectionable insecticides that could be used later in the season, but nothing can be recommended at present.

GRAPE LEAFHOPPER

The grape leafhoppers (*Erythroneura comes* (Say) and related forms) are small, agile, white or pale-yellow insects with red or yellow markings, often noted as abundant during the summer on the lower surface of grape leaves (fig. 14, *b* and *c*.) They feed by sucking

juices from the leaves, causing the foliage to become blotched with white (fig. 14, *a*) and later to turn brown; many of the leaves fall from the vines. This injury interferes with the proper ripening of the fruit and prevents normal vine growth. The insects pass the winter in the adult stage in protected places, usually in trash on the ground in or close to vineyards. With the first warm days of spring the leafhoppers become active and feed to some extent on any green vegetation they can find, concentrating their activity on the grape leaves as soon as these push out. Eggs are laid in the leaf tissue, and the young leafhoppers feed on the lower surface of the leaves. There are two or three generations of these insects each season.



FIGURE 14.—Grape leafhopper: *a*, Mottled appearance of injured grape foliage; *b*, adult leafhoppers; *c*, nearly full-grown nymph. (Insects about 10 times natural size.)

Control

The grape leafhopper may be controlled by spraying with nicotine sulfate (40 percent nicotine) at a strength of three-eighths of a pint to 50 gallons of either soapy water or bordeaux mixture. For small quantities, three-fourths of a teaspoonful of nicotine sulfate per gallon of spray should be used. The application should be made when the wingless leafhoppers, or nymphs, of the first brood are present in large numbers (in the North this will be late in June or early in July), as can be determined by examination. The spray should be directed toward the lower surface of the leaves, since this is where the nymphs feed. Under eastern conditions one thorough, well-timed application is usually sufficient. Commercial contact sprays containing pyrethrum or derris have been used successfully in grape leafhopper control.

These materials vary in composition, and the directions on the label should be followed. Wherever the leafhoppers are found hibernating in waste land in or close to vineyards their numbers may be greatly reduced by burning over such areas. For this purpose burners such as are used for heating pavements or for the destruction of weed growth can be used to advantage.

GRAPE ROOTWORM

The grape rootworm (*Fidia viticida* (Walsh)), infests the roots of the grape (fig. 15), as the name indicates, devouring more or less



FIGURE 15.—Injury done by the grape rootworm to the roots of a grapevine.

completely the small roots and rootlets, and eating pits and burrows into the outer portion of the larger roots. In the adult stage this insect is a small, hairy, chestnut-brown beetle that makes its appearance in vineyards at about the close of the blooming period of such varieties of grapes as Concord, Niagara, and Catawba. The beetles

feed on the upper surface of the leaves, eating a series of patches or holes through to the lower surface that take the form of characteristic chainlike feeding marks (fig. 16). The injury to the foliage, however, is quite unimportant as compared with the work of the larvae on the roots.

Control

The grape rootworm may be controlled in the adult stage by spraying the foliage with lead arsenate or calcium arsenate, 1 pound in 50 gallons of either water or bordeaux mixture, when the characteristic feeding marks first appear on the leaves. Spraying after the grape clusters have formed, however, should be avoided.



FIGURE 16.—Feeding marks on grape leaf made by the grape rootworm beetle.

ROSE CHAFER

In a number of localities in eastern United States the rose chafer (*Macrodactylus subspinosus* (F.)) causes severe injury in the early season to grape foliage, blossoms, and newly set grapes (fig. 17). The beetles are very general feeders and injure a large number of different kinds of fruits and ornamental plants. They sometimes migrate into the vineyard in large numbers and consume most of the foliage, leaving only the larger veins. Their feeding period lasts from 3 to 4 weeks.

This insect breeds largely in light sandy soils. In the larval stage it is a small white grub.

Control

The use of lead arsenate sprays when the beetles first appear in the vineyards is of considerable value for control, although complete elimination of the insects is not possible. The arsenical should be used at the rate of 5 to 6 pounds per 100 gallons, preferably in bordeaux mixture, and should be applied just as the blossoms are opening. Because of the danger of spray residue, applications of the material at this strength should be completed before the berries have formed (see pp. 17 and 20).

If the insects are found to be breeding in rather restricted sandy areas, much can be done toward control by thorough cultivation of such areas during the spring or early summer. At that time the insect



FIGURE 17.—Adult female rose chafer. About four times natural size.

is in the pupal stage and is readily injured by any disturbance of the soil.

LEAF-EATING CATERPILLARS

A large number of different caterpillars feed on the leaves of grapevines.

The grape leaf folder (*Desmia funeralis* (Hbn.)) is an active, grass-green caterpillar about three-fourths of an inch long that rolls or folds the leaves (fig. 18) and then feeds within the shelter thus formed.

The larva of the eight-spotted forester (*Alypia octomaculata* (F.)) is a little more than an inch long and has black and orange stripes across the body and a distinct hump near the hind end (fig. 19).

Several species of hornworms often cause injury to grape leaves, sometimes completely defoliating the vines. These are large caterpillars from 2 to 3½ inches in length. One of the more common hornworms, the achemon sphinx (*Pholus achemon* (Drury)), is illustrated in figure 20.



FIGURE 18.— Injury done by the grape leaf folder to a grape leaf.

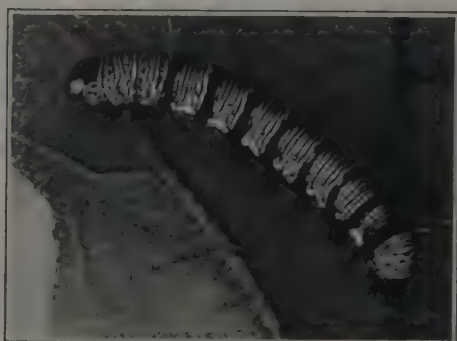


FIGURE 19.— Larva of the eight-spotted forester. (About twice natural size.)

Control

The leaf-chewing caterpillars are usually controlled by the second and third spray applications listed in the spray program given on page 27. If the caterpillars are found in numbers later in the season, special applications of lead arsenate or calcium arsenate, 1 pound in 50 gallons of either water or bordeaux mixture, may be necessary. When such later applications are made the spray should be directed from above and care should be taken to prevent undue contamination of the grape clusters.

In small plantings most of the leaf-eating caterpillars may be controlled by hand-picking.

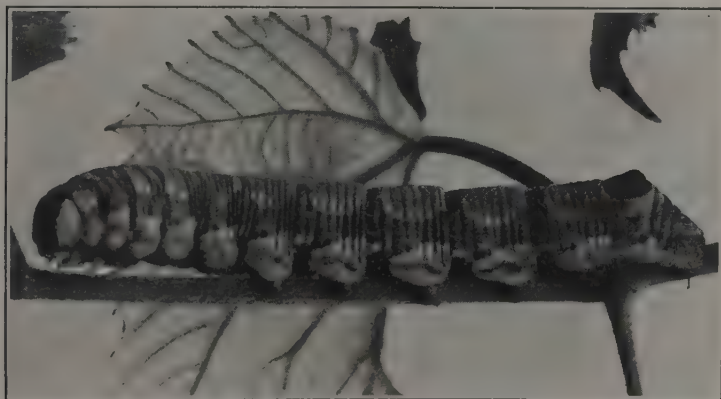


FIGURE 20.—The achemon sphinx, one of the common hornworms injuring grape leaves. (A little more than natural size.)

GRAPEVINE APHID

In vineyards east of the Mississippi River large numbers of tiny dark-brown grapevine aphids (*Aphis illinoisensis* (Shim.)) are often found during the summer on the young shoots and leaves (fig. 21). When the aphids are very abundant they may travel to the fruit clusters, causing some of the grapes to drop. In the fall the aphids leave the grapevines and migrate to the blackhaw (*Viburnum* sp.), where they spend the winter and spring months, returning to the grapevines early in the summer.

Control

The grapevine aphid may be controlled by spraying the vines with a contact insecticide after the insects appear. For this purpose three-eighths of a pint of nicotine sulfate (40 percent nicotine) in 50 gallons of water is most often used. A small quantity of soap should be added, or the nicotine sulfate should be combined with bordeaux mixture in one of the regular spray applications.



FIGURE 21. The grapevine aphid on grape shoots and young leaves.

GENERAL RECOMMENDATIONS FOR GROWING SOUND FRUIT

DISEASE-RESISTANT VARIETIES SUITABLE FOR HOME GARDENS

The standard varieties of bunch grapes grown in eastern United States are important commercially not only because they possess excellent table qualities, are suitable for making juice or wine, or are especially adapted to certain soils and climates, but also because their diseases and insect pests can be successfully controlled without much trouble and expense.

Under field conditions, where the vines are pruned regularly, sanitary measures are practiced, and spraying is properly done when needed,

diseases cause very little concern to the growers. Often, the same varieties, grown in home gardens where the vines are crowded, shaded, and indifferently pruned, will be diseased badly, even if sprayed frequently. It is advisable sometimes for those wishing to grow a few grapes in a garden plot to select varieties primarily from the standpoint of disease resistance, with some sacrifice of quality of fruit. There are a few varieties of fair to good quality that can be grown, at least in the Northeastern States, with little or no spraying. The variety Lutie would be worth trying. It is productive, the fruits are large and of fair quality, and it is resistant to black rot and downy mildew. In regions where downy mildew need not be considered, the varieties Campbell Early, Delaware, Lucile, and Worden would be suitable, provided they are adapted to such regions.

BAGGING THE FRUIT

Those growing a few grapes for home consumption as well as the more extensive growers producing for a discriminating market can afford to cover the fruit clusters with ordinary paper bags soon after the blossoms fall. Five-pound paper bags are suitable. The mouth of the bag should be either tied securely around the stem of the cluster or folded over the vine above the cluster in such a manner as to allow the corners to be pinned or fastened with paper clips. This should furnish the clusters ample protection against insects and infection by rot fungi throughout the season.

SANITATION

Since the fungi causing grape diseases live over winter in an inactive state on or within the old foliage, shattered fruit, or the vines, it is obvious that, if any of this infected material can be disposed of in some manner prior to the unfolding of the new leaves and the development of new spring shoots, correspondingly less disease should follow. The annual pruning of the grapevines undoubtedly takes out of the vineyard a large amount of infected material, because the fungi causing black rot, anthracnose, downy mildew, dead arm, and other diseases of less importance may attack and live over winter on the vines. Removing and burning canes infected with the dead arm fungus is the most effective method of combating that disease. Measures for controlling anthracnose also include removing and burning infected shoots.

Some cultural practices recommended as an aid in controlling the grape berry moth should also be of help in controlling all diseases that are carried through the winter on old leaves or on shattered diseased fruits. A shallow cover of soil over the old leaves and fruits will prevent the carrying of the spores to the new leaves and shoots by the wind or by the spattering of rain. In small home-garden plantings the leaves and dropped fruits can be gathered and burned during the fall, a practice that will be helpful.

SPRAY MATERIALS

The spray materials mentioned in this bulletin can usually be obtained from local agricultural supply houses. They are as follows.

Bordeaux Mixture

Bordeaux mixture may cause gastric disturbances if taken internally. All unused portions should be disposed of or covered in order to be inaccessible to children and animals. It is also somewhat irritative to the eyes and skin.

Bordeaux mixture is a spray to be prepared at home and used within a few hours. There are a number of substitutes on the market, under various names, in the form of either powders or pastes. They are convenient to use but less effective than the home-prepared product.

The ingredients of bordeaux mixture are bluestone (copper sulfate), lime, and water. For the spraying of grapes the proportions commonly used and recommended are 4 pounds of bluestone, 4 pounds of hydrated lime, and 50 gallons of water. The powdered and the "snow" forms of bluestone are preferred, as these forms dissolve quickly in water. The most convenient and available type of lime for this purpose is hydrated lime, which is used in the building trade. To prepare a 100-gallon spray tank of bordeaux mixture, fill the tank about two-thirds or three-fourths full of water, start the motor to operate the agitator, and pour in 8 pounds of the powdered or the snow form of bluestone. When this is completely dissolved, which will require about 5 minutes, pour in 8 pounds of hydrated lime and then add water to fill the tank. The spray is then ready for use.

To prepare a small quantity of bordeaux mixture for spraying a few vines in a home vineyard, use 2 level tablespoonfuls of bluestone and 6 of hydrated lime to each gallon of water. This spray can be mixed in the spray receptacle or tank. To each gallon of water add the required amount of bluestone and stir until it is dissolved, then pour in the lime and stir again; after the spray has been well stirred it is ready for use. If an insecticide or a sticker, such as soap or oil, is to be used, it should be added to the bordeaux spray as the last step.

Calcium Arsenate and Lead Arsenate

Calcium arsenate and lead arsenate are powdery materials that are used as stomach poisons. In the pure form these chemicals are white, but when they are sold for insecticides they are now usually colored pink to prevent their being mistaken for sodium bicarbonate, baking powder, or other substances about the home. **They are deadly poisons and should be stored where children and domestic animals cannot gain access to them. While handling, mixing, and applying these substances full face protection is recommended.** They should ordinarily be used at a strength of 1 pound in 50 gallons of water. For small quantities this is equivalent to approximately 3 rounded teaspoonfuls of either material per gallon.

Nicotine Sulfate

Nicotine sulfate may be bought in the form of a concentrated solution containing 40 percent of nicotine. In mixing small quantities it should be used at a strength of $\frac{1}{4}$ to 1 teaspoonful to each gallon of bordeaux mixture or of water. If it is used with water, enough soap should be added to make the water soapy to the touch. The exact amount of soap needed varies with the hardness of the water, but it is ordinarily $\frac{1}{2}$ to 1 ounce per gallon.

Other Contact Sprays

Sprays containing pyrethrum or derris, or extracts from these materials, are sometimes used for the control of grape leafhoppers and aphids. These spray materials are on the market chiefly in the form of proprietary products that differ a great deal in their composition and in their content of the active ingredients. They should be used in accordance with the manufacturer's directions found on the label.

Stickers

Commercial growers in many eastern sections use rosin-fish-oil soap or fish oil to cause the arsenicals and bordeaux mixture to adhere better to the smooth surface of the grape berries. In fruit-growing centers these materials may usually be obtained readily; elsewhere, they are seldom carried in stock. A convenient substitute is linseed oil. The soap should first be mixed with a small quantity of water and then added to the spray mixture; linseed oil or fish oil should be added last. The spray liquid should then be pumped back into itself until the oil is thoroughly mixed.

GENERAL SPRAY PROGRAM FOR GRAPES

The spray schedule given in table 1 is general in nature and requires modification to adapt it to the needs of each particular locality. More detailed information can be obtained from the local county farm adviser, the State extension service, or the State agricultural experiment station.

It cannot be too strongly emphasized that in the spray program the early sprays are most important. Infection of leaves and canes must be prevented if clean fruit is to be produced. Little can be accomplished if spraying is postponed until the fruit begins to rot.

TABLE 1.—General spray program for control of grape diseases and insects¹

Application	Time of spray application	Materials	Disease or insect requiring control	Remarks
No. 1...	When new shoots are 7 to 8 inches long.	4-4-50 bordeaux mixture...	Fungus diseases...	In sections where black rot is serious it is essential to make also an earlier application of 4-4-50 bordeaux mixture when the young shoots are only 1 to 2 inches long.
No. 2...	1 week before the blooming period.	4-4-50 bordeaux mixture, with 1 pound of calcium arsenate or lead arsenate and $\frac{1}{2}$ pint fish oil or linseed oil in 50 gallons of spray.	Grapeberry moth, leaf-chewing insects, fungus diseases.	
No. 3...	Just after the blossoms fall.	do.....	do.....	
No. 4...	2 weeks after the third application.	4-4-50 bordeaux mixture, with $\frac{3}{4}$ pint of nicotine sulfate (40 percent nicotine) and 1 pound rosin-fish-oil soap (or $\frac{1}{2}$ pint fish oil or linseed oil) in 50 gallons of spray.	Fungus diseases, grape leafhopper.	For control of the grape leafhopper, direct spray against lower surface of leaves.
No. 5...	2 to 3 weeks later, or when fruit is about half-grown.	4-4-50 bordeaux mixture	Black rot and other diseases.	

¹ This spray program will not be entirely suitable for the southern region of the eastern United States; see text, p. 28. Also see precautions, p. 26.

Difficulties in Controlling Grape Diseases in the South

On account of a long growing season and the frequency of rains in Florida and other South Atlantic and Gulf States, the simple spray schedule found so effective in controlling diseases in the region north of the Ohio River and east to the the Atlantic coast has been found inadequate. Therefore, if the reader resides south of Virginia, Tennessee, and Missouri he will do well, before planning his grape-spraying schedule, to consult with his county agricultural agent or write to his State college of agriculture for advice about the timing and number of applications needed.

Although four or five applications of bordeaux mixture may give very satisfactory control of black rot, downy mildew, and anthracnose in Michigan, the number of applications may need to be doubled in Florida to get as good results.

